REMARKS

Favorable reconsideration of this application, in light of the attached evidence and following remarks, is respectfully requested.

Claims 8, 10-14 and 18-21 are pending in this application.

Claim Rejections under 35 U.S.C. § 112, first paragraph

Claims 8, 10-14 and 18-21 stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written restriction requirement. In particular, the Examiner asserts the "claim(s) contains subject matter which is not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention." Applicants respectfully traverse this rejection as detailed below.

Claim 11

Regarding the use of the terms "inversely proportional" in claim 11 and new paragraph [0016.1], Applicants resubmit the following arguments, which are still believed to traverse this rejection to claim 11.

Applicants respectfully submit that support for pending claim 11 is found at least in paragraph [0017] and original claim 11 of the original specification filed on March 16, 2004. Further, Applicants respectfully note that paragraph [0017] of the original specification has been rephrased as permitted by MPEP § 2163.07, and the slightly rephrased version of paragraph [0017] was included as paragraph [0016.1] in the specification by the supplemental amendment filed February 2, 2007. Paragraph [0016.1] specifically recites the following.

> For example, the pressure applied to the scratcher is decided to be at a low level when the predetermined number of rotation turns of the optical disc is high,

> and at a high level when the predetermined number of rotation turns of the optical disc is low. Rephrased, the pressure applied to the optical disc is inversely related to the predetermined number of rotation turns of the optical disc according to this embodiment. The pressure applied to the optical disc is within the range of 500 to 1500 gf/cm^2.

Applicants respectfully submit the above paragraph supports the features recited in claim 11.

In light of the above, Applicants respectfully request that the rejection of claim 11 under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement, be withdrawn.

Claim 8

Regarding claim 8, the Examiner states the following "where is there support for 'determining the endurance of the optical disc based on a jitter value of 10%'? Please note that the single horizontal-line in FIG. 6 does not seem related to failure, as suggested on p.7 of REMARKS [included in the amendment filed June 14, 2007]. That single line is just there in FIG. 6."

Applicants again submit that the example graph illustrated in FIG. 6 of this application, and the description thereof, indicates how the jitter value may be used to determine endurance. Applicants submit the dotted horizontal line in Fig. 6 is not ***"just there"*** as asserted by the Examiner. In FIG. 6, as the number of rotations and the pressure applied to the disc increases, the jitter value increases. Further, when the jitter value becomes greater than about 10%, failures occur. As such, by obtaining the jitter value and then comparing the obtained jitter value to a threshold jitter value of 10%, one may determine the endurance. For example, one may determine a disc has sufficient endurance if the obtained jitter value is less than 10% according to FIG. 6.

Accordingly, Applicants submit that FIG. 6 does and the corresponding description in the specification does provide support for claim 8.

Claims 8, 10-14 and 18-21 also stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement.

Regarding claim 8, the Examiner asserts that the term "jitter value" is undefined, and proposes several questions. In response, Applicants provide a definition for jitter. **In general, "jitter"** is a classical term used in electronic engineering. The definition for jitter is given as follows:

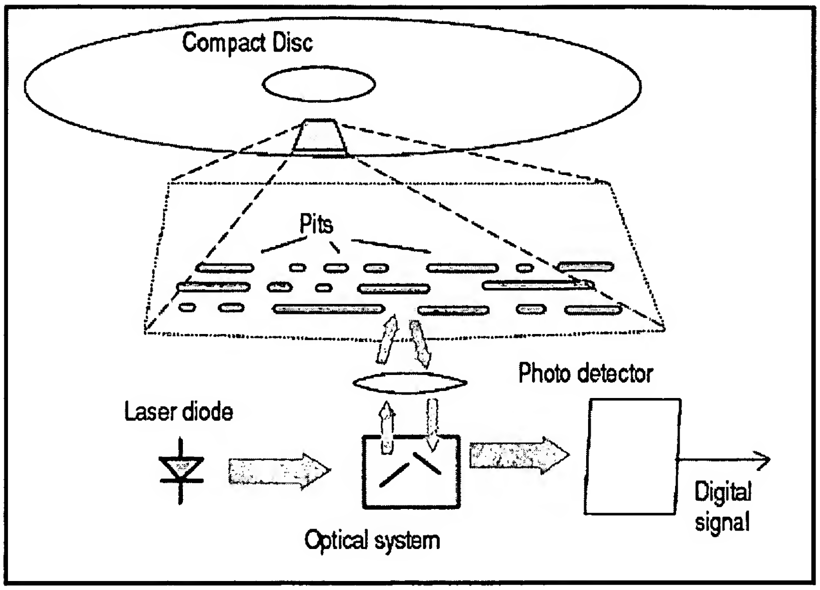
> Jitter: (A) Time-related, abrupt, spurious variations in the duration of any specified related intervals. (B) Amplitude-related ~ (same as (A)). (C) Frequency –related (same as (A)). (D) Phase-related~(same as (A)).

Please refer to the enclosed document A, photocopy of **"The IEEE Standard Dictionary of Electrical and Electronics Terms"**, sixth edition, issued on 1996. IEEE is an Institute of Electrical and Electronics Engineers. IEEE has members in over 175 countries and is the world's biggest expert institute in the field of electronic and electrical engineering, communication and computer.

Next, Applicants explain the usage of **jitter in optical disc**. Applicants also encourage the Examiner to refer to references titled "CD-jitter measurements" and "Jitter, what it is and how to measure it," which are identified as documents B and C, respectively, and are attached to the end of this Request for Reconsideration. A short review is provided below for the Examiner's convenience.

Digital information is recorded on the optical in the form of "pits". Several kinds of pits are used to record information on optical discs. For example, CD Standard employs nine different pits of different length. Sometimes, the length of pit is indicated in the unit of "T". For

example, CDs employ pits of lengths from 3T to 11T. The following figure illustrates an example of pits formed on a CD.



When the data on the optical disc is reproduced, the pits are converted into digital signal of corresponding length with respect to pits. Though the pits of same length, for example 3T, are reproduced, the length of digital signal may be different. (Here, length means time length, roughly speaking.) **That is, there is may be a variation in the length of reproduced digital signal from pits of same length.** **The variation is called jitter in the field of optical discs.** Smaller jitter generally guarantees better quality of an optical disc. So, **the jitter value is one of a criterion on every Standard in the optical disc, CD, DVD, BD and etc.**

The cause of jitter in the optical disc is as follows. Recorded pits are not accurate. Or reproduced signal of a pit can be influenced from other pits from adjacent tracks or same track. Or a scratch may cause larger jitter because the scratch can affect reproduced digital signal.

Lastly, Applicants note that test devices for measuring jitter value of an optical disc are on the market. A catalog for the devices is enclosed and identified as document D.

Regarding claims 18-21, Applicants respectfully submit that each of the terms "symbol error rate", "bit error rate", "servo error signal", and "tracking error signal" are well-known in the art and thus, the terms themselves do not need to be further defined. Further, Applicants respectfully submit that a "symbol error rate", "bit error rate", "servo error signal", and "tracking error signal" may be used in a similar manner as jitter value to determine endurance. Therefore, Applicants respectfully submit that at least FIG. 6 and paragraphs [0035]-[0037] of the specification provide an enabling disclosure for claims 18-21.

In light of the above, Applicants respectfully request that all of the rejections under 35 U.S.C. § 112, first paragraph be withdrawn.

Claim Rejections under 35 U.S.C. § 103(a)

Claims 8 and 10-14 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Hayashida et al. (U.S. Publication No. 2002/0054975, herein Hayashida).

Initially, Applicants respectfully note that the method for testing endurance of an optical disc of independent claim 8 recites, *inter alia*, "applying pressure on the optical disc using a scratching unit ***while the optical disc rotates for up to five rotation turns***, so as to produce a scratch on a surface of the optical disc, resulting from a contact with the scratching unit; and determining the endurance of the optical disc based on a jitter value of 10%." Applicants respectfully submit that at least the above-emphasized feature of amended independent claim 8 patentably distinguish over Hayashida.

In particular, paragraph [0091] of Hayashida, which is cited by the Examiner, specifically states that "[t]he abrasion test procedure using abrasive wheels prescribed by ISO 9352 is a test procedure commonly known as Taber abrasion test and is carried out as follows." The remainder of paragraph [0091] goes on to describe the well-known Taber abrasion test.

Applicants note the Taber abrasion test referred to in paragraph [0091] of Hayashida is specifically referenced in the "Background of the Invention" section of the Applicants' specification at page 3, paragraph [0007]. In particular, paragraph [0007] of the Applicants' specification states the following.

> Also, in the taber abrasion test, while using the abrasion wheel, the abrasive wear on the surface of the optical disc is very different from the scratches on the optical disc. Therefore, testing the endurance of the optical disc based on the abrasive wear caused by the abrasion wheel is not appropriate.

Applicants respectfully submit that this is evidence that the example embodiments described in the Applicants' specification and the features recited in amended independent claim 8 are not obvious in view of the Taber abrasion test.

Further, claim 8 recites "applying pressure on the optical disc using a scratching unit ***while the optical disc rotates for up to five rotation turns***." Regarding this feature, the Examiner identifies TABLE 3 of Hayashida as being "suggestive of the use of 5 cycles in an abrasion test" presumably because TABLE 3 includes a column heading of 5 Abrasion cycles. However, TABLE 3 provides no ground to limit the number of cycles to 5 turns since 0 to 500 turns are shown in the table. Further, paragraph [0091], specifically ***teaches away*** from using 5 cycles or less by saying "[f]or general hard coat layers in optical information media, it is preferred to abrade them by using elastic abrasive wheels selected from CD-10, CS-10F, and CS-17, and rotating the turntable ***over 10*** to 500 cycles under a load of 2.5 N to 9.8 N."

Accordingly, absent impermissible hindsight analysis, the teachings of Hayashida do not render obvious "applying pressure on the optical disc using a scratching unit ***while the optical disc rotates for up to five rotation turns***," as recited in amended independent claim 8.

In light of the above, Applicants respectfully submit that amended independent claim 8 patentably distinguishes over Hayashida and respectfully requests that the rejections of claim 8, and the claims depending therefrom, be withdrawn.

Request for Interview

Should the Examiner determine the above arguments and attached document A-D do not overcome the rejections, Applicants request the Examiner contact Applicants' representative at the telephone number below so that an interview can be scheduled to provide the Applicants with an increased understanding of what further evidence the Examiner would like to receive regarding the 112, first paragraph rejections. The requested interview will allow the Applicants to determine whether further claim amendments may be helpful or if an Appeal is the appropriate course of action.

CONCLUSION

In view of above remarks, reconsideration of the outstanding rejection and allowance of the pending claims is respectfully requested.

Pursuant to 37 C.F.R. §§ 1.17 and 1.136(a), Applicant(s) hereby petition(s) for a one (1) month extension of time for filing a reply to the outstanding Office Action and submit the required $120 extension fee herewith.

If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at number listed below.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 08-0750 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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Document A

IEEE Std 100-1996

The IEEE Standard Dictionary of Electrical and Electronics Terms

Sixth Edition

Standards Coordinating Committee 10, Terms and Definitions
Jane Radatz, Chair

This standard is one of a number of information technology dictionaries being developed by standards organizations accredited by the American National Standards Institute. This dictionary was developed under the sponsorship of voluntary standards organizations, using a consensus-based process.

ISBN 1-55937-833-6

90000

J

J *See:* joule.

Jabber A condition wherein a station transmits for a period of time longer than the maximum permissible packet length, usually due to a fault condition. (C/LM) 610.7-1995, 802.3u-1995

Jabber control The ability of a station to interrupt automatically the transmission of data and inhibit an abnormally-long output data stream. *Note:* This term is contextually specific to IEEE Std 802.3. (C) 610.7-1995

Jabber function A mechanism for controlling abnormally long transmissions (i.e., jabber.) (C/LM) 802.3u-1995

Jack (1) (electric circuits) A connecting device, ordinarily designed for use in a fixed location, to which a wire or wires of a circuit may be attached and that is arranged for the insertion of a plug. (PE) 43-1974r

(2) A connecting device within a circuit to which one or more wires may be attached and which is arranged so that a plug may be attached. *See also:* RJ-11; RJ-45. (C) 610.7-1995

Jack bolt (rotating machinery) A bolt used to position or load an object. (PE) [9]

Jacket (1) (cable) (electrical heat tracing for industrial applications) A thermoplastic or thermosetting plastic covering, sometimes fabric reinforced, applied over the insulation, core, metallic sheath, or armor of a cable. (BT/PE) [4], 152-1953s

(2) (primary dry cell) An external covering of insulating material, closed at the bottom. *See also:* electrolytic cell. (EEC/PE) [119]

(3) A polymeric sheath, sometimes fabric reinforced, applied over the insulation or core of a cable. (IA) 515.1-1995

(4) A protective covering over the insulation, core, or sheath of a cable. (NESC) C2-1997

Jack shaft (rotating machinery) A separate shaft carried on its own bearings and connected to the shaft of a machine. *See also:* rotor. (PE) [9]

Jack system (rotating machinery) A system design to raise the rotor of a machine. *See also:* rotor. (PE) [9]

Jacob's ladder *See:* ladder, rope.

Jaggies *See:* stairstepping.

Jam (1) (A) An external signal introduced deliberately into a transmission to prevent successful transmission. (B) A signal that carries a message that informs other stations that they must not transmit. (C) 610.7-1995

(2) A mis-feed in the feed mechanism of a printer or card reader. (C) 610.10-1994

Jamming A form of electronic countermeasure (ECM) in which interfering signals, typically noise-like, are transmitted at frequencies in the receiving band of a radar to obscure or distort the radar signal. (AE) 686-1990w

Jam strobe Indication of jammer azimuth bearing, one form being a marker on the radar PPI display. It can also show the jammer signal strength and severity of main and sidelobe jamming. (AE) 686-1990w

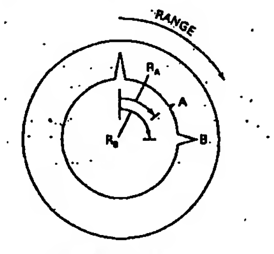
Jam transfer (hybrid computer linkage components) The transfer operation, in a double-buffered digital-to-analog converter (DAC) or digital-to-analog multiplier (DAM), in which the digital value is simultaneously loaded into both the holding and dynamic registers. (C) 166-1977w

Jansky (radio-wave propagation) A unit of spectral power flux density: 10^{-26} times one watt per square meter per hertz. (AP) 211-1990

Jar (storage cell) The container for the element and electrolyte of a lead-acid storage cell and unattacked by the electrolyte. *See also:* battery. (EEC/PE) [119]

JCL *See:* job control language.

J-display (A) A type of radar display format. *See also:* display. (B) A modified A-display in which the time base is a circle and targets appear as radial deflections from the time base.



Note: Two targets, A and B, at different ranges

J-display

(AE) 686-1990w

Jerk (inertial sensors) A vector that specifies the time rate of change of the acceleration; the third derivative of displacement with respect to time. (AE) 528-1994

Jitter (1) (A) (data transmission) (repetitive wave) Time-related, abrupt, spurious variations in the duration of any specified, related interval. (B) (data transmission) (repetitive wave) Amplitude-related, abrupt, spurious variations in the magnitude of successive cycles. (C) (data transmission) (repetitive wave) Frequency-related, abrupt, spurious variations in the frequency of successive pulses. (D) (data transmission) (repetitive wave) Phase-related, abrupt, spurious variations in the phase of the frequency modulation of successive pulses referenced to the phase of a continuous oscillator. *Note:* Qualitative use of jitter requires the use of a generic derivation of one of the categories to identify whether the jitter is time, amplitude, frequency, or phase related and to specify which form within the category, for example, pulse delay-time jitter, pulse-duration jitter, pulse-separation jitter. Quantitative use of jitter requires that a specified measure of the time or amplitude related variation, (for example, average, root-mean-square, or peak-to-peak) be included in addition to the generic term that specifies whether the jitter is time-, amplitude-, frequency-, or phase-related. (PE) 599-1985w

(2) (oscilloscopes, electronic navigation, and television) Small, rapid aberrations in the size or position of a repetitive display, indicating spurious deviations of the signal or instability of the display circuit. *Note:* Frequently caused by mechanical or electronic switching systems or faulty components. It is generally continuous, but may be random or periodic. (BT/PE) 201-1979w, 599-1985w

(3) (facsimile) Raggedness in the received copy caused by erroneous displacement of recorded spots in the direction of scanning. *See also:* recording. (COM) 168-1956w

(4) (pulse terminology) Dispersion of a time parameter of the pulse waveforms in a pulse train with respect to a reference time, interval, or duration. Unless otherwise specified by a mathematical adjective, peak-to-peak jitter is assumed. *See also:* mathematical adjectives. (IM) 194-1977w

(5) The time varying phase of a pulse train relative to the phase of the reference pulse train. *See also:* amplitude jitter; phase jitter. (C) 610.7-1995

(6) The time varying phase of a pulse train relative to the phase of a reference pulse train. For the specifications in IEEE Std 8802-5-1995, jitter is usually measured as the difference in edge times of the receiver's recovered clock or transmitter data output to a reference clock or data signal, typically the preceding station's transmitter clock or data output. The specifications are measured in nanoseconds. (C/LM) 8802-5-1995

(7) Refers to the time-uncertainty of a transitioning edge recurring in a repetitive signal. This uncertainty is only with respect to other edges in that signal. Jitter is commonly measured using random bit patterns and accumulating an eye pattern to show the worst-case difference in transitions. (C/MM) 1596.3-1996

(8) (A) Small, rapid variations in the size, shape, or position of observable information, frequently caused by mechanical and electronic switching systems or faulty components. It also refers to zero-mean random errors in successive target position measurements due to target echo characteristics, propagation, or receiver thermal noise. (B) Intentional variation of a radar parameter, for example, pulse interval. (AE) 686-1990w

Jitter, maximum output The peak-to-peak jitter acceptable to enable satisfactory interconnection of digital networks and equipment. (COM) 1007-1991

Jitter, timing Short-term deviations of the significant instants of a digital signal from their ideal positions in time. (COM) 1007-1991

Jitter tolerance, input The maximum level of input jitter, specified in terms of unit intervals peak to peak, that does not result in an onset of errors. (COM) 1007-1991

Jitter transfer function The ratio between input jitter and output jitter in specified frequency bands throughout the applicable jitter mask. The jitter transfer is controlled by the gain and cutoff frequency of the jitter transfer characteristic. (COM) 1007-1991

Jnd *See:* just noticeable difference.

Job (1) A user-defined unit of work that is to be accomplished by a computer. For example, the compilation, loading, and execution of a computer program. *See also:* job control language; job step; job stream. (C) 610.12-1990

(2) A set of processes comprising a shell pipeline, and any processes descended from it, that are all in the same process group. (C/PA) 9945-2-1993

(3) *See also:* batch job. (C/PA) 1003.2d-1994

Job control (1) A facility that allows users to selectively stop (suspend) the execution of processes and continue (resume) their execution at a later point. The user typically employs this facility via the interactive interface jointly supplied by the terminal I/O driver and a command interpreter. Conforming implementations may optionally support job control facilities; the presence of this option is indicated to the application at compile time or run time by the definition of the {_POSIX_JOB_CONTROL} symbol. (C/PA) 9945-1-1996, 9945-2-1993

(2) A facility that allows users to stop (suspend) selectively the execution of processes and continue (resume) their execution at a later time. The user typically employs this facility via the interactive interface jointly supplied by the terminal I/O driver and a command interpreter. Conforming implementations may optionally support job control facilities. The presence of this option is indicated to the application at compile time by the subtype `Job_Control_Support` in package `POSIX` or at run time by the value returned by the function `Job_Control_Supported` in package `POSIX_Configurable_System_Limits`. (C/PA) 1003.5-1992, 1003.5b-1995

Job control job ID A handle that is used to refer to a job. The job control job ID can be any of the forms shown in the table.

Job Control Job ID Formats

Job Control Job ID	Meaning
%%	Current job
%+	Current job
%–	Previous job
%*n*	Job number *n*
%*string*	Job whose command begins with *string*
%?*string*	Job whose command contains *string*

(C/PA) 9945-2-1993

Job control language (JCL) A command language used to identify a sequence of jobs, describe their requirements to an operating system, and control their execution. *Note:* Commonly used in batch-oriented environments such as IBM's 370 Computer. (C) 610.12-1990, 610.13-1993

Job function A group of engineering processes that is identified as a unit for the purposes of work organization, assignment, or evaluation. Examples are design, testing, or configuration management. (C) 610.12-1990

Job identifier A unique name for a job. A name that is unique among all other job identifiers in a batch system and that identifies the server to which the job was originally submitted. (C/PA) 1003.2d-1994

Job name A label that is an attribute of a job. The job name is not necessarily unique. (C/PA) 1003.2d-1994

Job-oriented terminal A terminal that is designed for a particular application, for example, a terminal used for airline checking or for point of sale. (C) 610.10-1994

Job owner The *username@hostname* of the user submitting the job, where *username* is a user name defined by Section 2.2.2.88 of POSIX.1 and *hostname* is a *network host name*. (C/PA) 1003.2d-1994

Job priority An attribute used in selecting a job for execution. A value specified by the user that may be used by an implementation to determine the order in which jobs will be selected to be executed. *Job priority* has a numeric value in the range −1024 to 1023. *Note:* The *job priority* is not the execution priority (*nice value*) of the job. (C/PA) 1003.2d-1994

Jobsite The assembly point at the structure or equipment where the workers, tools, and vehicles are assembled to perform the climbing to the worksite. (PE/T&D) 1307-1996

Job state An attribute of a batch job. The state of a job determines the types of requests that the batch server that manages the job can accept for the job. Valid states include QUEUED, RUNNING, HELD, WAITING, EXITING, and TRANSITING. (C/PA) 1003.2d-1994

Job step A user-defined portion of a job, explicitly identified by a job control statement. A job consists of one or more job steps. (C) 610.12-1990

Job stream A sequence of programs or jobs set up so that a computer can proceed from one to the next without the need for operator intervention. *Synonym:* run stream. (C) 610.12-1990

Jog (control) (inch) A control function that provides for the momentary operation of a drive for the purpose of accomplishing a small movement of the driven machine. *See also:* electric drive. (IA) [60], [75]

Jogging (packaging machinery) The quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine. *Synonym:* inching. (IA) 333-1980w

Jogging speed The steady-state speed that would be attained if the jogging pilot device contacts were maintained closed. *Note:* It may be expressed either as an absolute magnitude of speed or a percentage of maximum rated speed. *See also:* control system, feedback. (IA) [60]

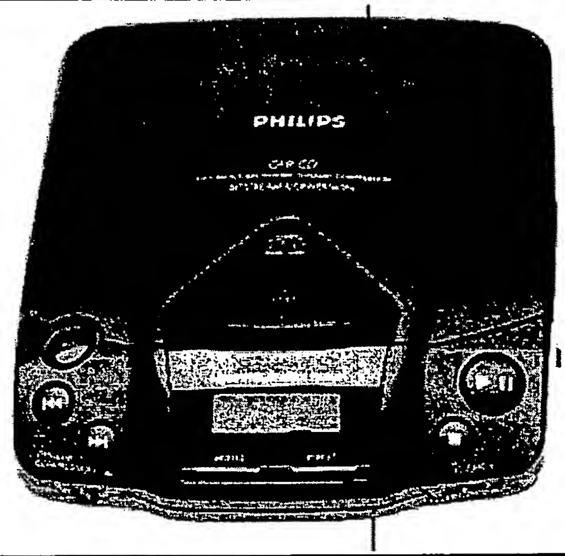
JOHNNIAC Open Shop System (JOSS) A procedural language used for performing numerical computations and mathematics. (C) 610.13-1993

Johnson noise (1) (interference terminology) The noise caused by thermal agitation (of electron charge) in a dissipative body. *Notes:* 1. The available thermal (Johnson) noise power N from a resistor at temperature T is $N = kT\Delta f$, where k is Boltzmann's constant and Δf is the frequency increment. 2. The noise power distribution is equal throughout the radio frequency spectrum, that is, the noise power is equal in all equal frequency increments. *See also:* signal. (IE) [43]

(2) (broadband local area networks) *See also:* noise; noise figure. (C/LM) 802.7-1989

Join A relational operator that combines two relations having a common attribute and which results in a relation containing

CD-jitter measurements



Background

The Compact Disc (CD) contains digitally stored information of for example audio, video or computer data. The digital signals are physically stored in a spiral track with a length of several km. The data is stored as a pattern of "pits" (cavities) and "lands" (the area between pits) in the CD surface. The length of the pits and lands are detected by an optical pick-up and transformed to electrical "digital symbols", used to reconstruct the audio signal. The data on the disc is recorded with a very high precision. The width of the cavities (pits) are only about 0.6 μm and the depth is about 0.12 μm.

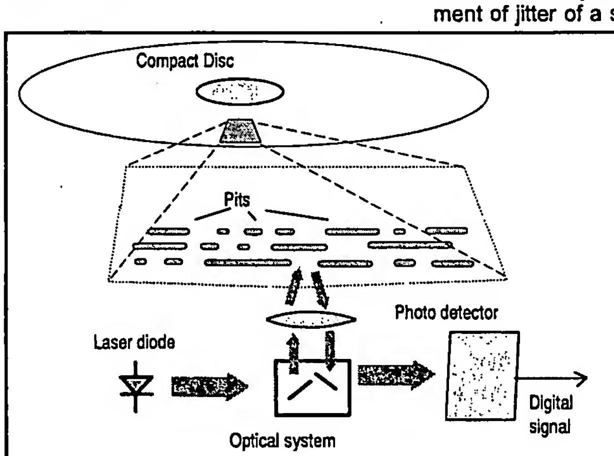


Figure 1 *Pits and Lands on a Compact Disc*

Nine different symbols called T3...T9 are used, both for pits and for lands (see fig. 1). Each symbol is represented by an electrical pulse having a width of 3...11 clock periods.

The importance of low jitter

The overall quality of the CD system is based on, amongst others, the amount of jitter in the system. The jitter could be caused by a bad recording or by the CD-player.

If the jitter is too large, the CD-player can't separate the various symbols, and the result will be a bad sound or wrong data interpretation in a CD-ROM system.

To maintain system quality, measurement of jitter of a selected symbol width is made at various stages in the production process. It is also important to verify jitter levels after repair of a CD-player.

Measurement of jitter is however not an easy task. For fast high performance measurement and analysis, expensive and complicated measuring systems are normally required.

Normal high resolution timer counters, even though they include statistic functions, can not measure these signals, since the symbol of interest must be extracted from the eight others by some sort of window technique.

Measurement problem

This application describes how a CNT-81 timer/counter/analyzer together with the PC-based TimeView analysis SW is used for quantifying the jitter in a portable CD-player.

Beside jitter analysis of the digital symbols, CNT-81 and TimeView can also be used to analyze the analog output signal from a CD-player. These further analysis include e.g. frequency stability analysis and detection of unwanted mains voltage modulation (50/60 Hz) of the system clock.

Tapping the unprocessed digital CD-signals

For correct measurements on digital signals in a CD player, the signal to be measured must be tapped early in the signal path, where it has not yet been frequency compensated (see fig. 2).

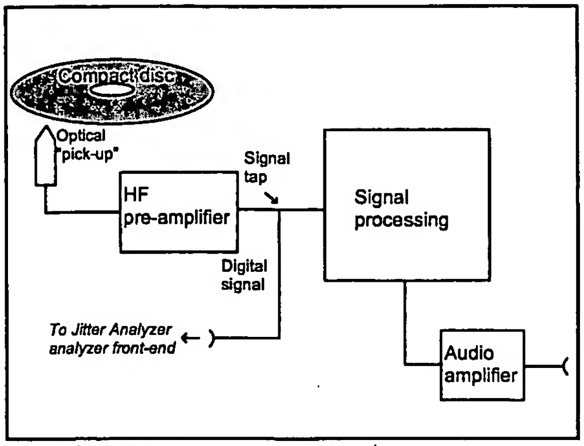


Figure 2 *Blockdiagram of CD-player*

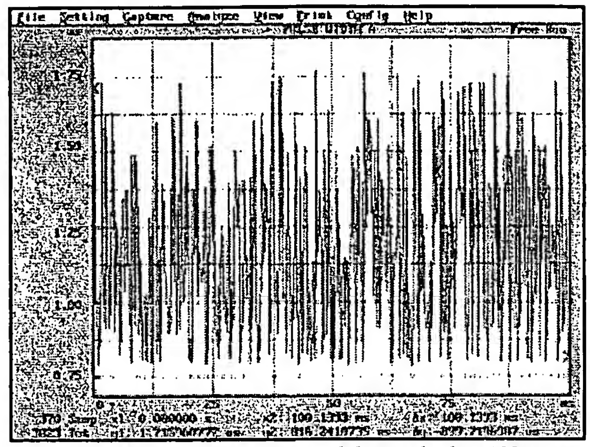


Figure 3 *The pulse widths measured during the first 100 ms shows a random pattern, and is difficult to interpret*

Measurement setup

The following description illustrates jitter measurements on the digital signal in a portable CD-player (Philips AZ 6821).

We rebuilt the player by tapping the signal early in the HF-pre-amplifier, where the output signal is a series of pulses with basically 9 different pulse widths . TimeView will show the amount of jitter present on the pulses. In other words, we will measure the *Pulse Width Jitter.*

In TimeView the measuring function was set to Pos. Pulse Width. Measuring time was set to minimum (80 ns) and SINGLE was ON.

The data capture via TimeView is made by free-run, single-block, capture. The number of samples was set to somewhat less than 4000.

The number of samples in itself is not critical. But notice that for highest TimeView capture speed in pulse width measurements, the sample size should be maximum 4466.

Data capture showing pulse width data vs time

The screen in figure 3 shows how the pulse width varies over time. The data is more or less a random pattern that is very difficult to interpret in a meaningful way.

However, by using the statistical function we can easily analyze the data. The distribution histogram of the pulse widths measured is shown in figure 4.

Statistical analysis quantifies jitter

Figure 4 shows the statistical distribution of the width of the 9 different symbols (T3...T11) on a CD, representing the nine different pit lengths.

In quality control and after repair it is of interest to analyze each of these clusters. In production testing, usually only the first population T3 is analyzed.

Let us zoom in by placing the cursors to the left and right of the first population.

As said, a quality criteria is the jitter data in the cluster. According to CD-standards this jitter must be less than 35 ns for an audio disk or a CD-ROM with single speed. For higher speeds, the demand for low jitter is increased.

Another important value is the effective length of the Pits or Lands, here found in the "text box" on the screen as a "Mean" value of 805 ns (depending on CD and actual trigger level settings). The jitter value (= "Stand Dev" in the text box) is found to be 13.1 ns.

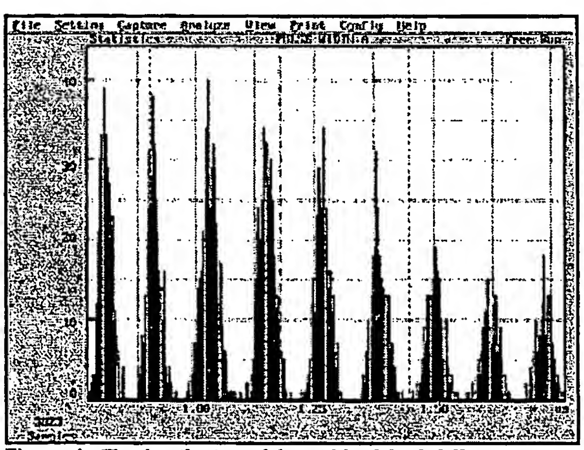


Figure 4 *The distribution of the width of the 9 different CD-symbols (T3...T11)*

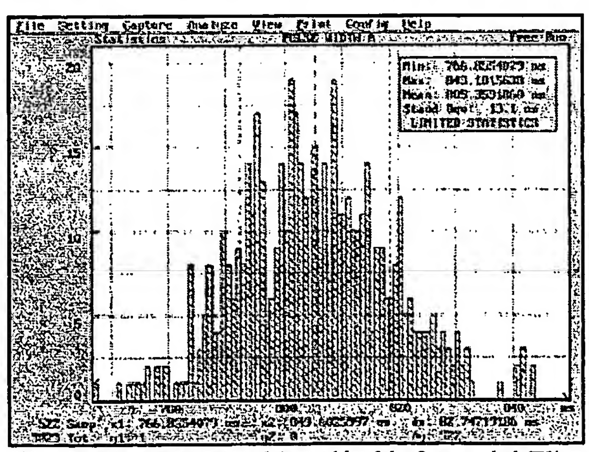


Figure 5 *The distribution of the width of the first symbol (T3)*

Jitter, what it is and how to measure it

This presentation was given by Dr. Jonathan Halliday, Research Director, NTE at REPLItech Santa Clara, 1996

What is jitter?

Jitter is not a new invention. It has always been with us. But now that the Red Book for CD has been extended to include a specification for jitter, it has become a buzzword; and for DVD, jitter is clearly going to be a very important thing to test.

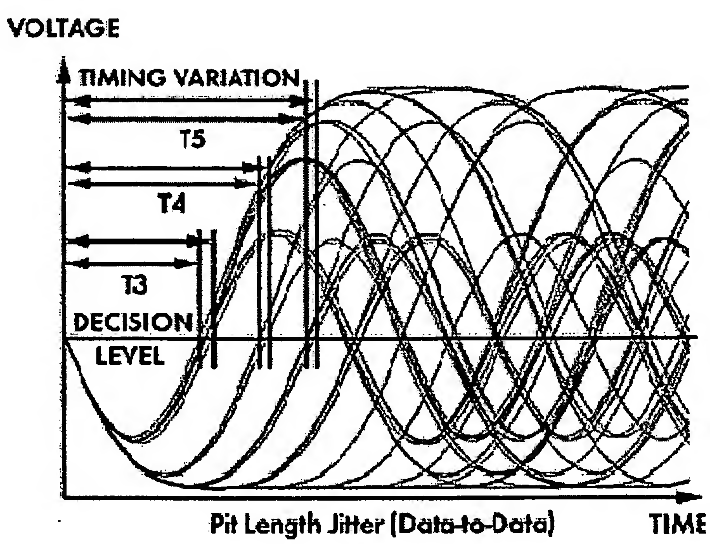
So let us consider what matters when we play a CD. Ultimately, the only thing that matters is that there should be no uncorrectable errors. But how do we make sure of this in production? We use a measurement called the block error rate (BLER), which counts erroneous data blocks and is an indication of the general quality of the disc. If the BLER is high enough, then there are likely to be uncorrectable errors.

Then let us take the argument another step back. What causes erroneous data blocks? A block is erroneous because at least one data symbol was read wrongly, and this happened because at least one pit or land length was wrongly recognised. And that happened because the transition between a pit and a land happened in the wrong place - there was a timing error.

Of course there are timing errors all the time. Not all of them cause data to be read wrongly; this only happens if the error is large enough. But a measurement of jitter is a measurement of the general level of timing errors that are happening, and if the jitter is high enough, then there are likely to be erroneous data blocks.

In short, a high BLER is an early warning that there may be uncorrectable errors; and, in turn, a high jitter level is an early warning that the BLER may be high. This makes it a useful measuring tool in CD production.

There are, naturally, a number of black boxes on the market for measuring jitter. But if we want to go back to basics, we can always look at the HF waveform on an oscilloscope.

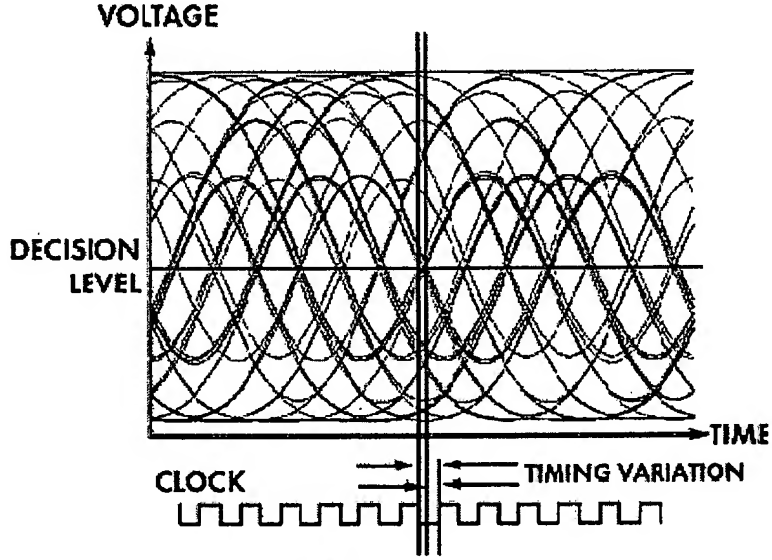


The type of waveform we get from a CD is fairly well-known. You can draw an imaginary line through the central intersections of the diamond patterns, and this is the decision level. Any part of the

waveform above this line will be read as a logic "1", and any part below the line will be a "0". The places where the waveform crosses the line ought to be uniformly spaced, but in practice there is always some variation in this timing. That variation is jitter.

Because the oscilloscope is triggered by the signal itself, we can see the jitter in the different pit lengths (such as 3T, 4T, 5T) separately. The other thing we can see is the "deviation" for each pit length. This is a measure of how different a given pit length appears to be from what it should be. So, for example, the usual tendency is for the shortest pits (the 3T pits) to appear a little shorter than 3T. Jitter and deviation are two aspects of the same thing: jitter is the random variation, and deviation is the average error, in the apparent length.

But there is a slightly different way of looking at the same HF signal. Every CD player has to extract a regular clock signal from the data, before it can decide how long the various pits are. The clock is used to sample the data before it is sent on into the decoder. If we use this clock, rather than the data, to trigger the 'scope, we get a different picture.



Data-to-Clock Jitter

If we now look at the timing variations where the HF signal crosses the decision level, what we are seeing is the jitter between the data and the clock. Now the timing of the crossing point can move up to half a clock cycle away from where it should be, before there is an error. So the condition for no errors is that the peak data-to-clock jitter is less than half a clock cycle (= 0.5T).

Clearly this is really what matters - the data-to-clock jitter - because it relates to what actually happens in the player. Now, at the moment, all the commercial equipment for measuring CD jitter measures data-to-data jitter, and that is the way the Red Book jitter specification is worded. But data-to-clock is clearly the more significant measurement.

Causes of jitter

Maybe we should be surprised that jitter is not more of a problem. CD recording and playback is not nearly as well understood theoretically as digital radio links and the like. Not only is the record and replay process limited by the resolution of the optical pickup, it is also horribly non-linear. In addition, the playback of the pits is subject to non-linear crosstalk from nearby pits in the same track, and also

from pits in nearby tracks. It is not obvious that the waveform that comes out is going to be easily decoded.

So the interesting thing is that the playback of the recorded pits is as good as it is, and that the signal waveform crosses the decision threshold at roughly the right time intervals. It is only the small errors in those timings which we have to be concerned with - in other words, the jitter.

Sources of Jitter

The things that cause jitter divide into three main types. First, the recorded pits themselves are not perfectly accurate. Anything which causes unwanted variations in the sizes of the pits will come out as jitter. One thing that can be significant is laser noise; that is, high-frequency variations in the power of the recording spot. Not surprisingly, if the power varies, the pits also vary in width and length, so when the CD is played the apparent pit lengths vary. But, more generally, the physical process of mastering and replication introduces variability at all stages. We can refer to everything under this heading as "process noise".

Generally we find that jitter from process noise is less when the pit shapes are sharply defined, with steep sides - although this does not always go with good mouldability, nor with strong push-pull tracking signals! Remarkably low jitter is possible with UV mastering of standard CDs. A different recording spot profile (elliptical spot) can also reduce the effect of process noise by improving the resolution along the track (so the pit ends are sharper). But process noise is not necessarily easy to judge by looking at SEMs or AFMs, as what matters is not so much the pit shape itself as the subtle unwanted variations between one pit and the next.

But even if the pits were perfectly recorded and replicated, there would still be jitter. This is because of the limited resolution of the pickup in the player. Our second source of jitter is the influence of other pits nearby in the same track. The readout spot is broad enough that when the centre of the spot reaches the beginning of a short pit, the end of the pit lies within the fringes of the spot. So the apparent position of the one pit end is slightly dependent on where the other end is. The same applies to short lands. This is called inter-symbol interference. The jitter which arises from this is not truly random, but is associated with the pattern of recorded pit and land lengths.

Inter-symbol interference is worse at low recording velocities, because the pits are shorter and closer together. And it is the cause of "deviation" of the pit lengths. After all, if all the recorded pits were the same size, they would have to be the correct length on playback, because the total number of pits per

unit length could not change. If the shortest pits appear too short on playback, it is only because most of them are next to lands which are longer.

The pit lengths can be deliberately modified during mastering to compensate for inter-symbol interference, because the sequence of pit lengths is known. But it is something to use with caution - the inter-symbol interference depends on the player, and there is always a danger of making the playback worse on some players.

Finally, our third source of jitter is the crosstalk between pits in adjacent tracks, because the readout spot does not fall wholly on one track. It is a largely random contribution. It is worse at lower recorded velocities, because the highest frequency components of the readout signal in the wanted track, with which the crosstalk is competing, are weaker.

With all these forms of jitter, there is one feature of a CD player which generally makes a marked improvement, and that is equalisation. It is a gentle boost of the higher frequencies (so it relatively strengthens the signals from the shorter pits and lands), and to some extent it has the effect of correcting for the effects of the optical resolution limitations which cause inter-symbol interference and crosstalk. The deviation of the shorter pit lengths is likewise reduced. Not all CD players use it, but they ought to.

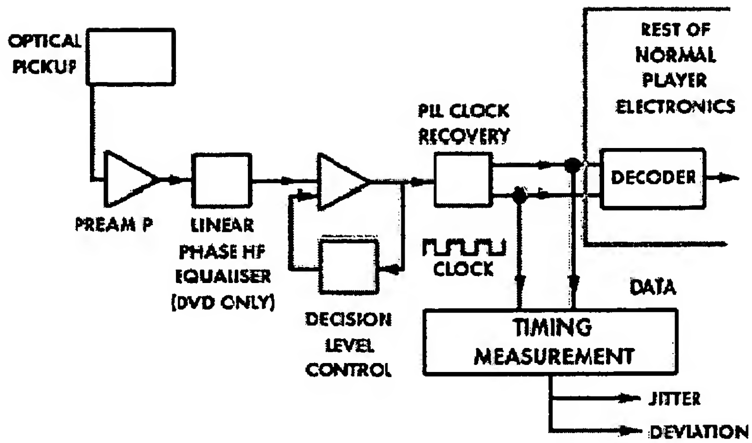
How to measure jitter

Now we come to the measurement of jitter - whether it be data-to-data or data-to-clock.

Data-to-data jitter readings are higher than data-to-clock, by up to 40%. This is because each data-to-data timing measurement is effectively the sum of two largely independent data-to-clock measurements (one for each end of a pit). The Red Book jitter limit is 35 nsecs, data-to-data. So if this was measured data-to-clock, the reading would be 25 nsecs, or perhaps a little higher.

The Red Book also gives deviation limits, and gives them separately for each different pit length. It is a curious feature of this specification that the deviation for the shortest pits is barely allowed to be positive. A "perfect" disc would appear to be near the edge of the specification. This seems to be an acceptance that most discs in the market have a negative deviation for short pits, and that the decoding chips in many players do actually go some way towards compensating for these typical deviations.

Now here we have the front end of a player, with data and clock signals being taken off before the decoder stage to go into a timing measurement "box". This box captures the timings of many data and clock edges at high speed, and then processes the information contained in those timings. But we should take a look at those front-end stages. They can all influence the performance of the system.



Jitter Measuring System Front End

Firstly, the optical response of the pickup must be up to a uniform standard. The Red Book does specify the optical characteristics (wavelength, numerical aperture, the illumination of the aperture, polarisation, and wavefront quality) of the pickup for jitter measuring purposes - although the polarisation specified is different from the one used for other Red Book measurements! - but it does not say anything about ordinary players. Measuring systems do in practice use the same types of pickup as domestic players, but some care must be taken in choosing them, or the results could be pessimistic. Also it must be remembered that when we test discs against the given specification, we are really supposed to be testing the jitter attributable to the disc alone, after eliminating any contributions due to imperfections of the players.

After the pickup, there is a preamplifier for the HF signal - not forgetting that signals for focusing and tracking also have to be extracted from the same pickup.

In a normal CD player this stage may be followed by an HF equaliser. This is important. The right equalisation substantially improves jitter performance, and jitter is sensitive to changes in the equalisation. But the CD Red Book jitter specification requires a pickup without equalisation. So if there is equalisation in a player, it has to be bypassed for measurement purposes. The response of the circuit which remains must then be a good broadband one, otherwise the result could again be pessimistic.

The best CD players do use equalisation, and are much less sensitive to jitter than those without. If all CD players used an equalising filter, jitter would be much less of a problem. As it is, the manufacturers of discs are being asked to tighten up their specifications in order to allow for the cheapest players.

With DVD the situation will be a little different, starting afresh. Because DVD performance is more critical (system margins are tighter by a "magic factor" of 1.5 compared with CD), one can expect that all players will have to use equalisation as a matter of course. So if all jitter measurements are likewise done with an equalised signal, they will be more indicative of real performance than they are for CD.

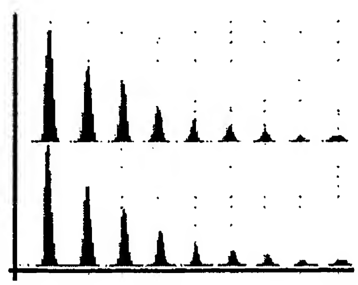
The high-frequency boost in the equaliser should be a linear phase filter, since the optical playback properties are also linear phase. Not all electronic filters are like this. The point is that the kinds of degradation which the optical playback process introduces are symmetrical under time reversal, so the electronic circuit which corrects for these degradations should have the same property. The wrong kind of filter can introduce inter-symbol interference, which makes the measured jitter worse.

After the equaliser stage comes an adaptive clipping circuit, or comparator. This sets a decision level and converts the analogue signal into digits. The decision level is controlled usually by keeping the average duty cycle in the digitised signal at 50%. The response time of this circuit is important. It has to respond fast enough to compensate for variations such as variable development of the master as it rotates, but not so fast that the decision level varies with the pattern of the HF modulation as it goes past, otherwise it would introduce inter-symbol interference on its own account.

Next comes a phase-locked loop arrangement to extract the clock from the data. In data-to-clock measurement, and indeed in real players, it is important that the clock edge which samples the signal is placed (on average) halfway between the data edges, otherwise the player will be more sensitive to jitter than it need be. The loop must be fast enough to track apparent speed variations due to eccentricity, orange-peel, etc., but not so fast that the clock timing is itself altered by the pattern of pit and land lengths on the disc.

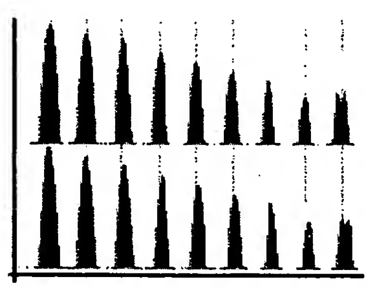
Now, how to display the results of our measurements?

Data-to-data jitter is usually displayed as a series of histograms, one for each pit and land length - 18 in all. The usefulness of this is that the different average deviations for each pit length can be highlighted.

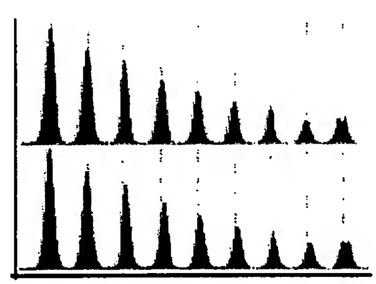


Data to Data Jitter - Linear Scale

Here we are showing them on a linear vertical scale. The tight clustering of each peak around the ideal length, and the wide gaps between the peaks, are an indication of low jitter. The fact that the various peaks are not precisely centred on the vertical lines which represent the nominal lengths is an indication of the deviation in each measurement. This was a UV-mastered CD at 1.2 metres per second, with data-to-data jitter of 9% to 10% of T (20-22 ns).



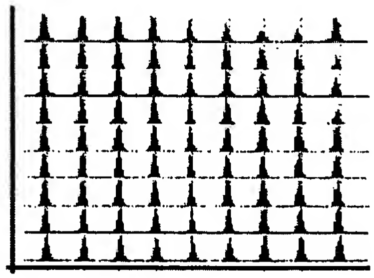
Data to Data Jitter - Log Scale



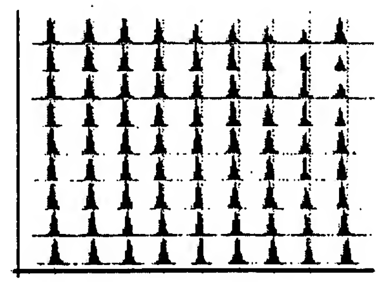
Data to Data Jitter - Quadratic Scale

This may be a more familiar display of the same data. The vertical scale is logarithmic. It expands some detail in each histogram, but loses the "tail" of each shape altogether.

This scale is also used in commercial equipment. The vertical height goes as the square root of the actual value. It gives a good compromise between high and low level detail.



Data to Clock Jitter - Falling Edge



Data to Clock Jitter - Rising Edge

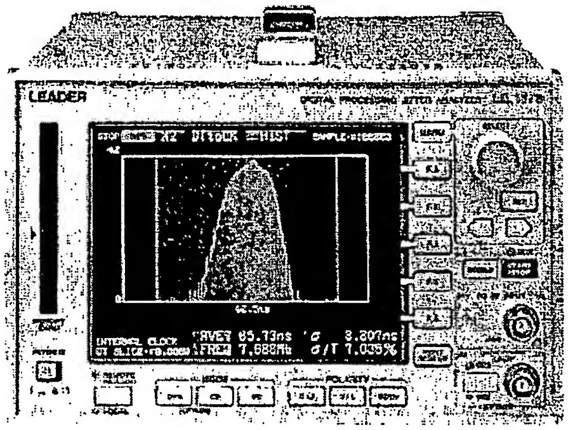
Now, if we think about data-to-clock jitter measurements, it is not meaningful to classify them according to pit length, since that is not what we are measuring. Rather, each measurement is of a pit/land transition, relative to the clock. We have two extreme options. One is to amalgamate all the measurements into a single histogram. The other is to classify every reading according to the pit and land lengths which adjoin each transition. If we do the latter, we get 81 separate histograms for falling edges (that means going from a land to a pit), and another 81 for rising edges (from pit to land): 162 in all. This enables us to be very analytical, for the various deviation effects (due to inter-symbol interference) can be separated out from other sources of jitter. (This was not so with the 18-histogram display.) You can see, for example, in each column, how the rising edge gets later (relative to the clock) as the land length which follows it gets shorter. This is the characteristic behaviour of the deviation - the apparent position of the pit/land edge is shifted towards the pit or the land, whichever is shorter, thus making it appear shorter still.

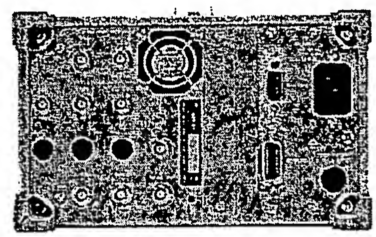
The other thing you can see is an anomaly due to the fact that these particular measurements were made using the clock generated by a standard decoder chip. The timing of the rising edge is not behaving as expected along each row of the display, and that is an indication that the chip's clock recovery circuit is actually compensating for it. The answer is not to rely on the chip's clock, but to generate from it a separate, smooth clock using a straightforward conventional phase-locked loop. If this is done, the anomaly disappears.

AUDIO

LEADER

Applicable to Blu-ray Disc
Ideal for Analyzing Jitter of x1, x2-Speed Disc and Optical Pickup





LE 1876 DIGITAL PROCESSING JITTER ANALYZER

●GENERAL

The LE 1876 Jitter Analyzer is designed to measure the jitter conforming to Blu-ray Disc (Part 1, version 1.0, June 2002) standards.
Since the Limit Equalizer (applicable to x2 speed of Blu-ray Disc standards), PLL clock regenerator, and jitter measurement section are provided as standard, x2 speed of HF signal can be measured.
A large LCD panel displays jitter in histogram format, this instrument can be used for analyzing jitter.
Jitter measurement units for a DVD/CD or HFM are optionally available. Thus, jitter of DVD and CD, and HF and HFM of Blu-ray Disc can be measured using a single unit.
Optional GPIB and LAN are convenience to construct an automatic measurement system and ensure quality control.

●FEATURES

[Features on Blu-ray Disc measurement]

- **Equipped with the Equalizer conforming to Blu-ray Disc standards**
  The Conventional Equalizer and Limit Equalizer conforming to x1 speed described in Blu-ray Disc standards are provided as standard. The Conventional Equalizer mode and Limit Equalizer mode are selectable. The boost level of pre-Equalizer can be varied.
- **Applicable to three types of media**
  Jitter of Blu-ray Disc with disc capacity of 23.3 GB, 25.0 GB, and 27.0 GB can be measured.
- **Measures the jitter of all-T components conforming to Blu-ray Disc standards (Also applicable to x2 speed)**
  Measures all components of 2T to 8T and 9T of the HF (DATA) signal with respect to the CLOCK signal, then displays it as jitter in sigma format.
  Various jitter measurement modes (e.g., sum of all-T components, each T in pulse width mode) are also provided.
- **Confirming to x2 speed prescribed in Blu-ray Disc standards**
  The equalizer applicable to the x2 speed confirming to Blu-ray Disc standards is provided to measure jitter of x2 speed HF (DATA) signal.
- **Three polarity modes**
  Rising edge, falling edge, and both edges of HF (DATA) signal can be selected.
- **Applicable dual-layer disc**
  The 2T component can be eliminated in DATA to CLOCK measurement mode used when inspecting a dual-layer disc.

[Features on Measurement]

- **High sensitivity**
  The HF (DATA) with a signal level between 0.1 Vp-p and 2.0 Vp-p can be measured.
- **Various monitor outputs**
  Input signal and equalized signal can be monitored.
  DC voltage in proportion to the meter indication is output.
- **Frequency check mode**
  Clock signal frequency regenerated by the PLL can be measured.
- **Auto slicer**
  Auto slicer conforming to Blu-ray Disc standards is provide.
- **Displaying jitter in unit of ns or %**
  The absolute jitter value can be displayed in units of nanoseconds (ns). Jitter can also be displayed in units of percentage (%) measured with respect to the clock signal.
  No period setting is required since the clock is automatically regenerated from the HF (DATA) signal.
- **Jitter measurement in time domain format**
  Jitter of all-T components in the HF (DATA) signal is displayed in histogram format.
- **Simultaneous display of jitter in histogram format and sigma value**
  Jitter can be simultaneously displayed on the large color LCD panel in histogram format, sigma value, and average value. The clock frequency can also be displayed simultaneously.
- **Jitter variation measurement mode**
  Since jitter in sigma value and average value can be displayed in time domain format, long-term measurement and management are possible.
- **ARMING/INHIBIT capabilities**
  Two useful modes are provided: INHIBIT function to inhibit jitter measurement of faulty block (e.g., track jumping) on a disc, ARMING function to set the block to be measured.
  The delay time, measurement time, and number of gating operations with respect to the ARMING/INHIBIT signal applied can be set.
  The gating status can be monitored on the oscilloscope through the monitor output.
- **One-shot measurement mode**
  Repetition and one-shot measurement modes are provided.

[Features on Production Line]

- **GO/NO GO judgment mode convenient for production line**
  HF (DATA) signal jitter measurement results are compared with the preset judgment limits, then results are displayed on the LED. The result can also be output.
- **Simple operation**
  Speed, judgment reference, number of sampling, response time, and slice level can easily be set with a jog dial.
- **Universal voltage**
  Since this instrument operates on 90 to 250 V, it can be used throughout the world.

LEADER

AUDIO

SPECIFICATIONS LE 1876

Input Section
HF INPUT (1-7 modulation signal input)
Input Coupling: AC
Measurement Voltage Range: 0.1 to 2.0 Vp-p
Input Range: 3 ranges
0.3 V range: 0.1 to 0.3 Vp-p
0.9 V range: 0.3 to 0.9 Vp-p
2.0 V range: 0.9 to 2.0 Vp-p
Input Impedance: 50 Ω
Auto Slicer: AUTO (Response time constant x1 speed: 10 kHz x2 speed: 20 kHz)
Maximum Input Voltage: ±2.5 V

Measurement Control (ARMING IN/INHIBIT IN)
Input Impedance: 10 kΩ
Input Signal Level: 0 /+5 V
Maximum Input Voltage: -0.7 V/+5.7 V

Equalizer Section
(1) x1 Speed
Conforms to Blu-ray Disc (Part 1, version 1.0) standards.
Applicable Format: 1-7 PP modulation
Channel Bit Rate: 66 MHz
Equalizer Mode: Conventional Equalizer Mode or Limit Equalizer Mode, selectable
Conventional Equalizer
Gain Variable Range: 0 to 8 dB (36 steps)
Gain Accuracy: ±0.5 dB
Group Delay Deviation: ≤2.0 nsp-p (5.8 dB: 3 MHz to 16.5 MHz)
(2) x2 Speed (Undecided)
Applicable Format: 1-7 PP modulation
Channel Bit Rate: 132 MHz
Equalizer Mode: Conventional Equalizer Mode or Limit Equalizer Mode, selectable
Conventional Equalizer
Gain Variable Range: 0 to 8 dB (36 steps)
Gain Accuracy: ±0.5 dB
Group Delay Deviation: ≤2.0 nsp-p (5.8 dB: 6 MHz to 33 MHz)

Jitter Measurement Section
Applicable Speed: Applicable Speed
HF: Clock frequency
x1 speed: 66 MHz ±4 %
x2 speed: 132 MHz ±4 %
Measurement Mode: DATA to CLOCK, PERIOD mode, sum of all-T data in PERIOD mode, PULSE WIDTH mode, sum of all-T data in PULSE WIDTH mode, D to C2E
Measurement Resolution: 12.5 ps min.
Display Resolution:
max. min: 12.5 ps min.
σ, AVERAGE: 10 ps min.
σ/T: 0.01% min.
Measurement Accuracy
Sigma Value: ±5 %
Polarity Selection
DATA: ⎍/↑, ⎎/↓, BOTH
CLOCK: ↓ (fixed)
Measurement Item: AVERAGE, max, min, σ, σ max, σ min, σ/T, σ/T max, σ/T min
Unit Displayed: ns, %
Measurement Results Display: Numeric value, bar graph, histogram, TIME DEVIATION, BOTH for separate display
Number of Samples: 1,000,000 max.

Measurement Control Section (ARMING/INHIBIT function)
Measurement Control: ARMING mode/INHIBIT mode
Electrical Characteristics
Input Impedance: 10 kΩ
Input Signal Level: 0 /+5 V
Maximum Input Voltage: -0.7 V/+5.7 V
INHIBIT
ENABLE: HIGH/LOW
COUNT: 1 to 50, in 1 steps
ARMING
SLOPE: RISE/FALL
COUNT: 1 to 50, in 1 steps
START DLY: 0 to 999999 µs (in 1 µ steps min.)
LENGTH MODE: SAMPLE/TIME
LENGTH: 0.01 to 999999 µs (in 1 µ steps min.)(TIME only)

Clock Regenerator (DATA to CLOCK mode only)
Regenerates reference clock signal from DATA signal input.
HF: x1 speed: 66 MHz ±8 %, x2 speed: 132 MHz ±8 %

Clock Frequency Measurement Section (DATA to CLOCK mode only)
Measurement Range
HF: x1 speed: 60.72 MHz to 71.28 MHz
x2 speed: 121.44 MHz to 142.56 MHz
Measurement Accuracy: ±0.1 %

Judgment Section
Outputs GO/NO GO results of jitter and frequency measured with respect to the preset value.
LCD Panel: Judgment results for selected measurement item
Selected item: σ, σ max, σ min,σ/T, σ/T max, σ/T min, max, min, AVE, DEV, DEV max, DEV min, FREQUENCY

Output Section
MONITOR OUT
To monitor the HF signal input.
Output Impedance: 50 Ω
Output Amplitude: Up to 2.0 Vp-p ±30 % (into 50 Ω, in proportion to input signal)
Output Connector: BNC
EQUALIZER OUT
To monitor equalized HF signal input.
Output Impedance: 50 Ω
Output Amplitude: 0.8 Vp-p ±30 % (into 50 Ω)
Output Connector: BNC
DIGITAL OUT (DATA, CLOCK)
Outputs binarized DATA signal and clock signal regenerated by PLL.
Output Signal: DATA signal, CLOCK signal
Output Amplitude: 0.15 Vp-p (into 50 Ω)
Output Offset Voltage: 0.34 V (into 50 Ω)
Output Connector: BNC
DC OUT
Output Accuracy: ±2 %
Output Item: Jitter (full scale voltage variable)
Maximum Input Voltage: 2 V
GATE MONITOR
To monitor arming/inhibit control signals.
Output Amplitude: TTL level
Output Impedance: 1 kΩ

Remote Control Section
Dedicated Remote Control Connector
Communicates judgment results and front panel settings.
Front Panel Setting Pins
Input Level: 0 /5 V(pulled-up with 47-kΩ resistor)
Maximum Input Voltage: -0.7/+5.7 V
Judgment Results Output Pins
GO: +5 V (open drain output, pulled-up with 47-kΩ resistor)
NO GO: 0 V
Maximum Current Output: 10 mA

RS232C Interface
Communication: Controls function, outputs data.
Baud Rate: 38400 bps max.

Others
Display Mode: HIST: Histogram
BAR: Bar graph
DATA: Statistical value
TIME: Time deviation
JUDGE: GO/NO GO judgment
Store/Recall
Media: Internal memory, memory card
Items Stored: Measurement data (waveform), internal settings
Printing Screen Data
Print Media: Memory card
Memory Card
Applicable Card: Interface: Conforms to PC CARD ATA standards
Card Manufacturers Recommended: SanDisk
Display: 5.7" STN LCD, color, 1/4 VGA
Environmental Conditions
Operating: Temperature: 0 to 40 °C
Humidity: ≤ 85 % RH (without condensation)
Spec-Guaranteed: Temperature: 10 to 30 °C
Humidity: ≤ 85 % RH (without condensation)
Storage: Temperature: 0 to 50 °C
Operating Environment: Indoor use
Operating Altitude: Up to 2,000 m
Overvoltage Category: II
Pollution Degree: 2
Power Requirements: 90 to 250 VAC, 50/ 60 Hz, 35 Wmax.
Dimensions and Weight: 213 (W) x 132 (H) x 300 (D) mm, 4.7 kg
Accessories: power cord 1
Instruction manual 1

OPTION

OP71 DVD/CD Measurement
Input Section
DATA INPUT (EFM/8-16 modulation signal input)
Input Coupling: AC (2 Hz/1 kHz, selectable)
Measurement Voltage Range: 50 mV to 5 Vp-p
Input Impedance: 1 MΩ/50 Ω, selectable
Slice Level
VARIABLE: ±2.5 V
AUTO (ASYMMETRY ON): 20 Hz/1 kHz/5 kHz/10 kHz, selectable
Maximum Input Voltage: ±5 V
Jitter Measurement Section
Applicable Speed
DVD: Clock Frequency
PW, PD: 24.3 MHz to 59.4 MHz
DT to CK: x1 speed: 27 MHz ±10 %
x2 speed: 54 MHz ±10 %
CD: x1, x2, x4, x6, x8, x10, x12 speed
Measurement Mode
DVD: PERIOD mode, sum of all-T data in PERIOD mode, PULSE WIDTH mode, sum of all-T data in PULSE WIDTH mode, DATA to CLOCK
CD: PULSE WIDTH mode, sum of all-T data in PULSE WIDTH mode
Unit Displayed: ns, %
Measurement Resolution: 50 ps
Display Resolution: 0.01 ns
Measurement Accuracy
Sigma Value: ±4 % ±0.15 ns
Average Value: ±1 ns
Polarity Selection
DATA: ⎍/↑, ⎎/↓, BOTH
CLOCK: +, -
Measurement Item: AVERAGE, max, min, σ, σ max, σ min, σ/T, σ/T max, σ/T min
Measurement Results Display: Numeric value, bar graph, histogram, TIME DEVIATION, BOTH for separate display
Number of Samples: 1,000,000 max.
Clock Frequency Measurement Section (DVD, DATA to CLOCK mode only)
Measurement Range: 24.3 MHz to 59.4 MHz
Measurement Accuracy: ±0.1%
Clock Regenerator (DVD, DATA to CLOCK mode only)
Regenerates reference clock signal from DATA signal input.
HF: x1 speed: 27 MHz ±8 %, x2 speed :54 MHz ±8 %

OP72 HFM Measurement
Input Section
Input Coupling: AC
Measurement Voltage Range: 50 mV to 5 Vp-p
Input Impedance: 1 MΩ/50 Ω, selectable
Frequency Range: x1 speed: 8 MHz, x2 speed: 16 MHz
Slice Level: ±2.5 V (VARIABLE)
Maximum Input Voltage: ±5 V
Jitter Measurement Section
Measurement Range: Clock Frequency
PW: 3.37 MHz to 7.92 MHz
DT to CK: x1 speed: 3.667 MHz ±8 %
x2 speed: 7.333 MHz ±8 %
Measurement Mode: DATA to CLOCK, PERIOD mode, sum of all-T data in PERIOD mode, PULSE WIDTH mode, sum of all-T data in PULSE WIDTH mode
Measurement Resolution: 50 ps
Display Resolution
max. min: 50 ps
σ, AVERAGE: 10 ps
σ/T: 0.01 %
Measurement Accuracy
Sigma Value: ±5 %
Polarity Selection
DATA: ⎍/↑, ⎎/↓, BOTH
CLOCK: ↓ (fixed)
Measurement Item: AVERAGE, max, min, σ, σ max, σ min, σ/T, σ/T max, σ/T min
Unit Displayed: ns, %
Measurement Results Display: Numeric value, bar graph, histogram, TIME DEVIATION, BOTH for separate display
Number of Samples: 1,000,000 max.
Clock Regenerator (DATA to CLOCK mode only)
Regenerates reference clock signal from DATA signal input.
HFM: x1 speed: 3.667 MHz ±8 %, x2 speed: 7.333 MHz ±10 %
Clock Frequency Measurement Section (DATA to CLOCK mode only)
Measurement Range: x1 speed: 3.37364 MHz to 3.96036 MHz
x2 speed: 6.74636 MHz to 7.91964 MHz
Measurement Accuracy: ±0.1 %

OP73 GPIB (IEEE 488.1)
Function: Transfers data, controls front panel settings.

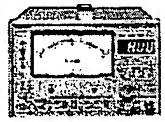
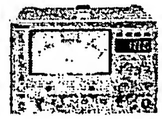
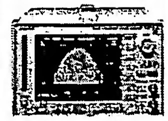
OP74 LAN
Function: Transfers data, controls front panel settings.

OP71 and OP72 can not be installed together.
OP73 and OP74 can not be installed together.

Selection Guide

DIGITAL PROCESSING JITTER METER

Applicable to Blu-ray Disc and DVD/CD (LE 1871/LE 1876)

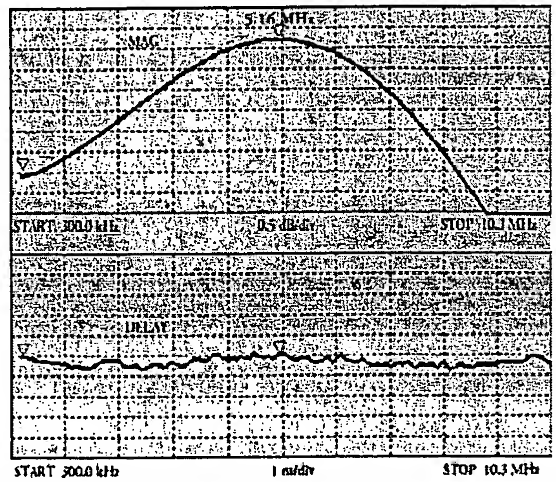
			JITTER METER		JITTER ANALYZER	
			 DVD/CD LE 1870	 Blu-ray Disc LE 1871	 DVD/CD LE 1875	 Blu-ray Disc LE 1876
Applicable Speed	Blu-ray Disc	x1 speed		○		○
		x2 speed				○
	DVD	x1 speed	○	Option	○	Option
		x2 speed	○	Option	○*4	Option
	DVD-RAM	2.6 G, 4.7 G			○*1	Option
	CD	x1 speed	○	Option	○	Option
		x2, x4, x6, x8, x10, x12 speed	○ *2	Option	○	Option
	CD-R (Bi-Phase)	x1, x2, — x32 speed	Option	Special order	Option	Special order
Measurement Mode	Blu-ray Disc	HF DATA to CLOCK		○		○
		HFM DATA to CLOCK		Option		Option
	DVD (ROM) DVD-R/RW	DATA to CLOCK	○	Option	○	Option
		DATA to CLOCK (2 inputs)		Special order	○	Special order
		PULSE WIDTH mode (3-11, 14T)	○ *2	Option*2	○	Option
		Sum of all-T data in PULSE WIDTH mode			○	Option
		PERIOD mode (6-25T)			○	Option
		Sum of all-T data in PERIOD mode			○	Option
	DVD—RAM	DATA to CLOCK (2 inputs)			○	Special order
		PULSE WIDTH mode (3-11, 14T)			○	Option
		Sum of all-T data in PULSE WIDTH mode			○	Option
		PERIOD mode (6-25T)			○	Option
		Sum of all-T data in PERIOD mode			○	Option
Equalizer	Blu-ray Disc	Conventional Equalizer		○		○
		Limit Equalizer		Option		○
	DVD (ROM) DVD-R/RW	Fixed boost level (3.2 dB)	Option		Option	
		Variable boost level (3.2 to 6.0 dB)	Option	Option *3	Option	Option *3
	DVD-RAM	2.6 G (for x1 speed)			Special order	Special order *3
		4.7 G (for x2 speed)			Special order	Special order *3
Interface	GPIB		Option	Option	Option	Option
	RS232C		○	○	○	○
	LAN			Option		Option

*1 DVD-RAM equalizer is required.
*2 For the LE 1870/LE 1871, 3T can only be measured in PULSE WIDTH mode; it cannot be selected via the front panel.
*3 Digital system is used.
*4 For the LE 1875, x1 and x2 speeds can be measured in PULSE WIDTH mode.

DVD Fixed Equalizer Option

- **3.2-dB boost level equalizer conforming to DVD book**
- **Usable for inspecting pickups**

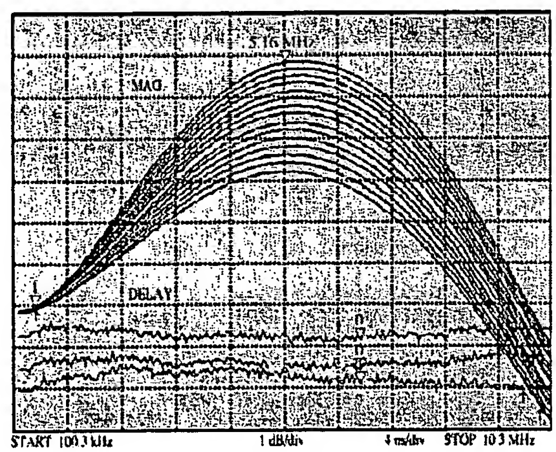
• Channel Bit Rate	27 MHz
• Boost Level	3.2 dB
• Boost Level Accuracy	±3 % (at 5.16 MHz)
• Group Delay Drift	2.5 ns max.



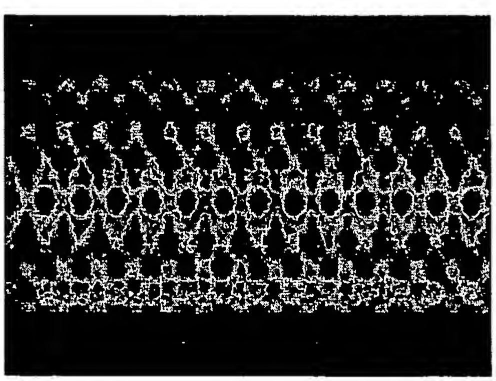
DVD Variable Equalizer Option

- **Variable boost level equalizer for jitter measurements**
- **Using an equalizer with a fixed boost level of 3.2 dB is recommended by DVD Book, however, applying a suitable boost level to an optical pickup ensures accurate jitter measurement and better productivity.**

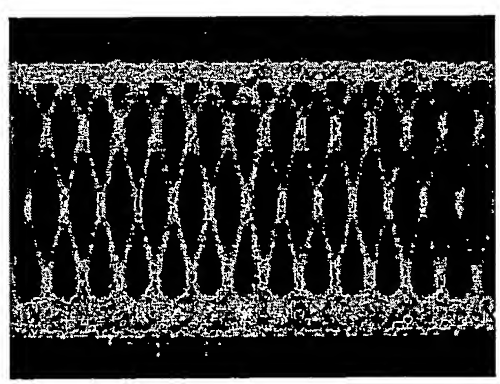
• Channel Bit Rate	27 MHz
• Valuable Boost Level	3.2 to 6.0 dB, in 0.2 dB steps
• Boost Level Accuracy	±3 % (in each step, at 5.16 MHz)
• Group Delay Drift	4 ns max.



Effectiveness of Blu-ray Disc Limit Equalizer



RF waveform without limit equalizer



RF waveform with limit equalizer